Underground Network System Strategy Executive Summary

Current State

Purpose

The purpose of the System Strategy is to outline a 10-year strategy for a discrete asset system. It provides a description of the investment, performance, key risks and intervention strategies associated with the asset system. The strategy also describes how the system is managed to achieve the network objectives and Endeavour Energy's key goals.

Context

Our regulatory asset base (RAB) is managed via discrete asset systems and subsequent classes within each system. The underground network has a population of 933,412 assets making up 33% of the total asset count across the RAB. Assets within the underground network contribute 29% of the BAU risk across the RAB. This system strategy covers Endeavour Energy's underground network assets. The underground network assets include the following classes (excluding oil filled cables).

- UG cables
- UG switchgear
- Services
- Pits, pillars, cubicles

Current Practice

Management of the underground network is driven by achieving the underground network objectives. Historic asset performance data is utilised to quantify current performance of the assets against the underground network performance targets. Historic failure data is utilised to inform the quantification of current and forecast asset risk. Risk is quantified in categories which are aligned to the underground network objectives. Intervention options are then assessed and selected based on their NPV and effectiveness in addressing the asset risk categories, Network Objectives and Underground System Objectives. Constraints are applied to optimise the list of proposed interventions. Ongoing monitoring of performance trends is undertaken to confirm effectiveness of proposed interventions and alignment with Network Objectives.

Proposed Strategy

Targets

Performance targets for the underground network are categorised as safety, reliability and bushfire. Specific performance targets include;

- Reduce 5-year rolling average of total incidents (excluding general hazards)
- Reduce 5-year rolling average of customer minutes interrupted

Strategy Options

To achieve performance targets and mitigate asset risk a range of intervention options have been considered including the below.

- Operational Controls
- Reduced Load
- Non-network
- Additional maintenance
- Reactive repair/ replacement
- Staged removal / Replacement

Strategy Selection

Reactive repair/replacement and staged removal/replacement are the preferred intervention options. Staged removal/replacement does not provide sufficient value for pits, pillars, cubicles or service mains.

The strategies presented in this report include:

- BAU
- Risk Based

1. Baseline – Business as usual (BAU).
2. Unconstrained – Inclusive of BAU plus risk based investments identified when they reach their maximum NPV (Risk Based).
3. Optimised – Inclusive of BAU plus unconstrained investments with cost considerations and comparison to other potential investments applied.

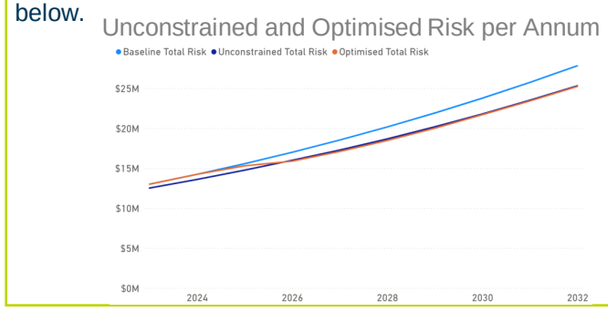
- UG switchgear
- Services
- Pits, pillars, cubicles
- UG cables

Forecast Outcomes

Performance Forecast

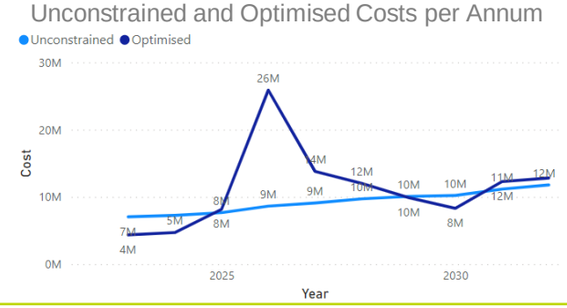
Risk Forecast

Over the next 10 years, proposed intervention strategies are forecast to mitigate underground network risk as summarised below.



Cost Forecast

To deliver the proposed underground network intervention strategy, required investment over the next 10 year planning period is summarised below.



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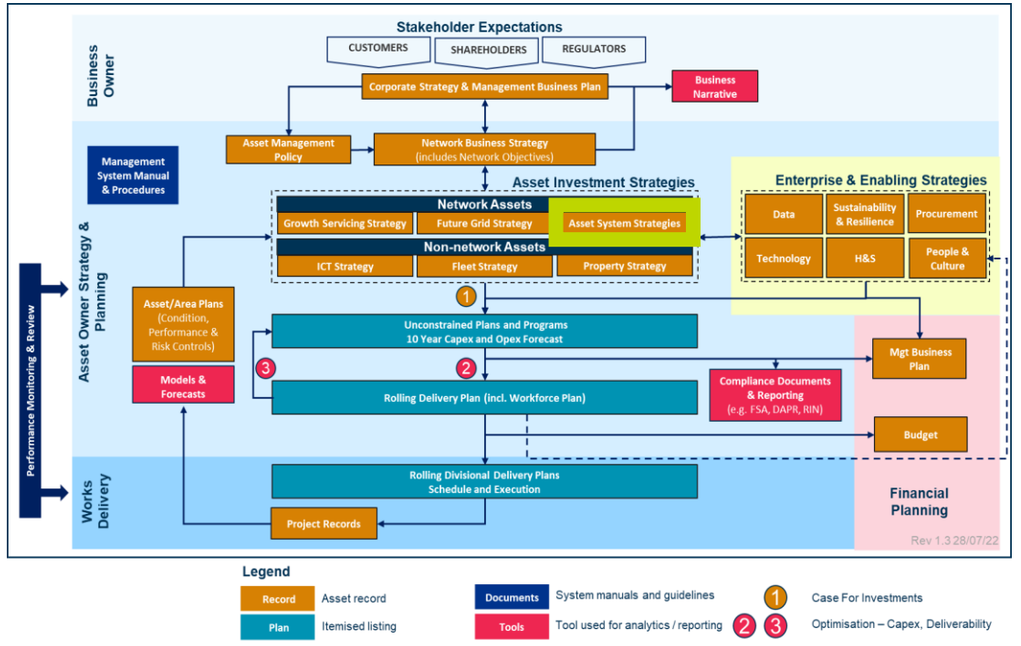
Version	Date	Comments
1.0	November 2022	Initial release

The purpose of this document is to outline current and proposed asset management practices for Underground (UG) Network assets (excluding oil filled cables), and define a 10-year strategic plan for the system based on risk and cost. The 10-year plan seeks to use all current knowledge of the system in context with the whole network to establish Key Performance Indicators (KPI) to assist in understanding and monitoring ongoing performance.

The relationship between this System Strategy and other artefacts within the Asset Management Framework (AMF) is illustrated below.

Asset Management Framework



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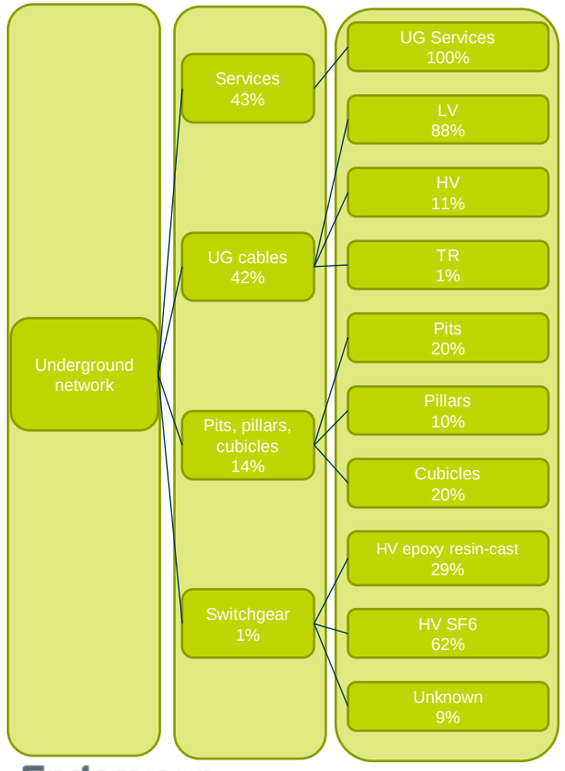
Overview

A 10-year strategy for the Underground (UG) Network system (excluding oil filled cables) has been defined, driven by the risk associated with the ageing population of the asset class. The forecasted risk, strategy, cost breakdown, and performance metrics are outlined in this report and include asset classes within the underground network scope. The strategies presented in this report include:

1. Baseline – Business as usual
2. Unconstrained – Inclusive of business as usual plus risk based investments identified when they reach their maximum NPV
3. Optimised – Inclusive of business as usual plus unconstrained investments with all constraints and comparison to other potential investments applied.

Scope

The Endeavour Energy RAB is managed via discrete systems and subsequent classes within each system. The scope of this document includes the underground network system.



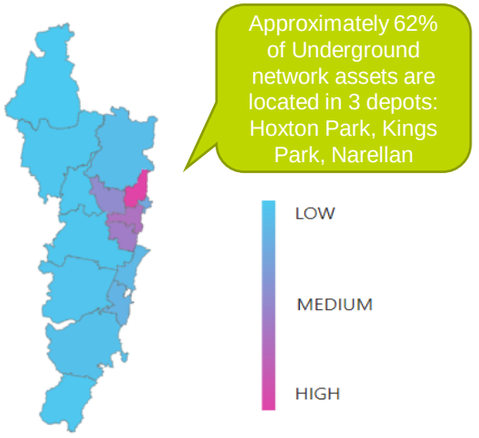
33% Assets within the underground network make up 33% of the **asset counts** across the regulated asset base[1].

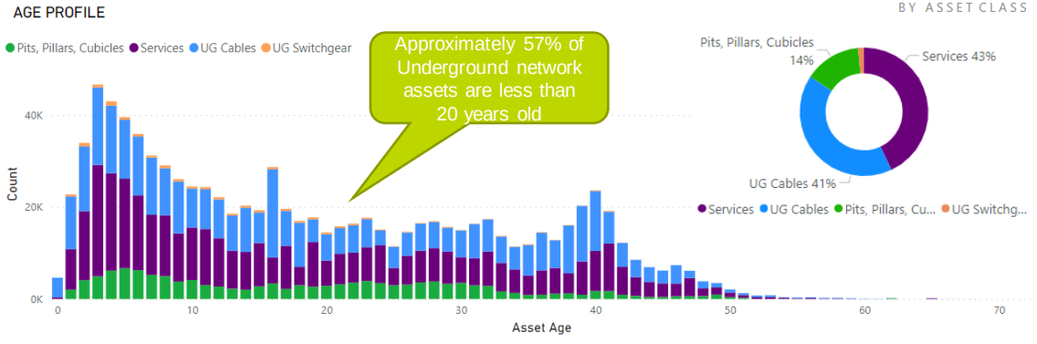
29% Assets within the underground network make up 29% of the **BAU risk** across the regulated asset base.

24% Assets within the underground network make up 24% of **cost** over the next 10 years across the regulated asset base.

1. *Based on counts of discrete assets per asset class plan breakdowns. Linear assets are counted based on GIS FID. Public lighting assets summarised as "bracket" or "lantern" rather than sub types articulated in the ACP.*

Density of underground network





Method

- Age profile
- System Performance Objectives selected in alignment with Network Objectives and historical trends identified
- Historical performance data identified for each consequence category
- Failure modes identified and probability of failure modelling undertaken
- Risk modelling undertaken to determine the quantum of risk relating to each category
- Intervention options assessed at system level and asset class level
- Economic assessment of intervention options undertaken to identify optimum balance of performance, risk and cost
- Future performance forecasts calculated (in development)
- Line of sight to Network Objectives to ensure targets are met (in development)

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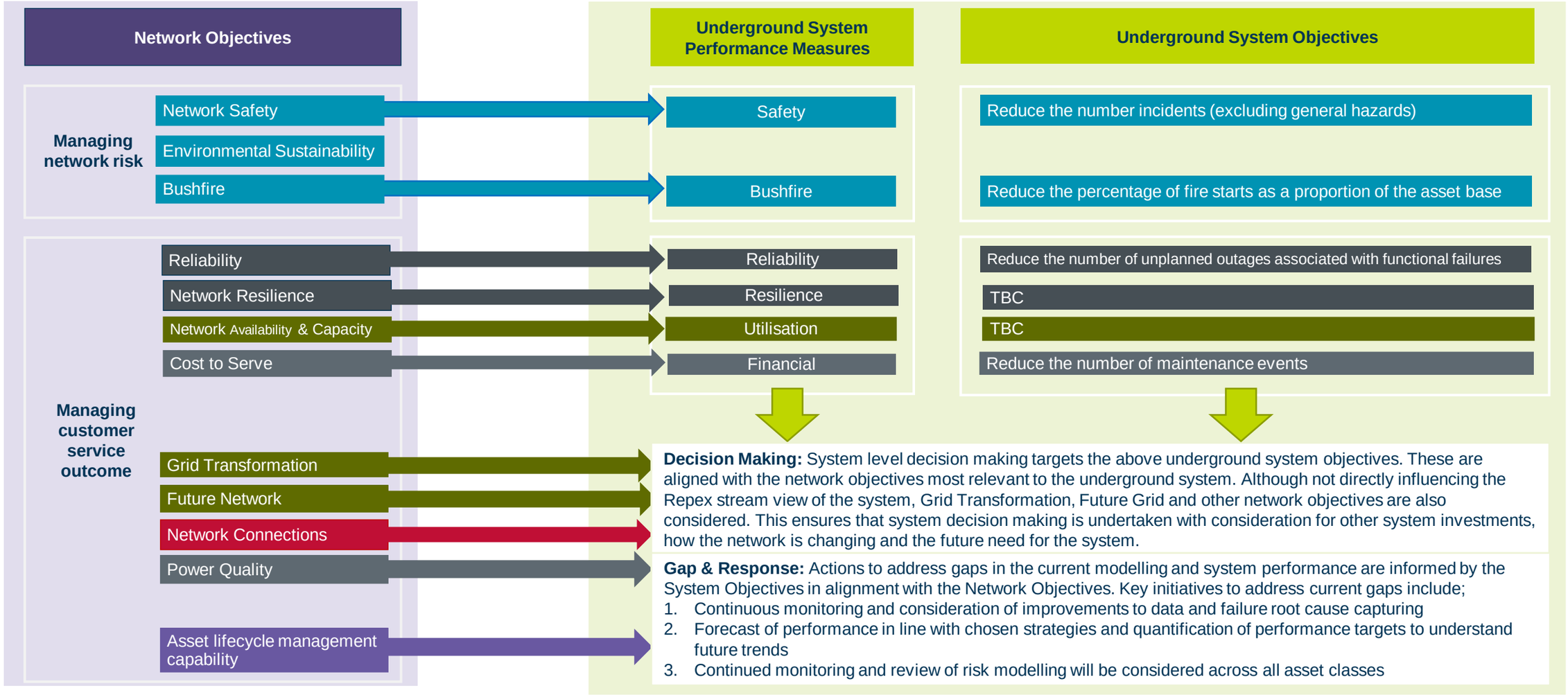
Network Objectives

Twelve network objectives have been identified to drive prudent investments to deliver against customers, shareholders, and regulators' expectations. Monitoring these objectives provides oversight against critical investments themes, allowing Endeavour Energy to manage appropriate trends and levels of investment for the future i.e. increase, decrease or maintain investment in key areas. As illustrated in the figure below, this System Strategy facilitates line of sight from the Network Objectives to the system performance targets and objectives.



Monitoring Network Objectives

Performance Category	Objective	Performance Measure	Asset Class	Current Performance	Performance Target	Status	Trend *
Utilisation	TBC						
Safety	Reduce the number incidents (excluding general hazards)	5-year rolling average of total incidents (excluding general hazards)	UG cables	N/A	Reduce in line with forecasts	●	—
			UG switchgear	3.3		●	—
			Pits, pillars, cubicles	4.4		●	—
			Services	1.25		●	—
Reliability	Reduce the customers minutes interrupted during unplanned outages associated with unassisted functional failures	5-year rolling average of customer minutes interrupted	UG cables	7.27 M	Reduce in line with forecasts	●	▲
			UG switchgear	-		●	—
			Pits, pillars, cubicles	0.14 M		●	—
			Services	0.24 M		●	—
Resilience	TBC						
Bushfire	Reduce the percentage of fire starts as a proportion of the asset base	5-year rolling average of fire starts	UG cables	N/A	Reduce in line with forecasts	●	—
			UG switchgear	N/A		●	—
			Pits, pillars, cubicles	N/A		●	—
			Services	N/A		●	—

Our response to achieving system performance targets?

- It is noted that only historical trends have been considered to date.
- Across all asset classes, risk based interventions proposed for the overhead system are expected to reduce risk and reliability incidents resulting from the ageing asset fleet.

A main contributor to safety events is UG Switchgear. To further minimise the number of safety incidents, continued monitoring and review of performance and risk modelling will be considered across all asset classes. Refined categorisation of safety incident data on MySafe will also be considered.

The largest contributor to reliability events are the UG cables. 60% of UG cable outages are due to defects in the LV cable connections.
To further minimise the number of functional failures, UG cables will continue to be monitored for reliability events. A further review of data capture and failure root causes across the network will also be considered to ensure failure data is correctly attributed to asset classes.

There are no bushfire risks captured for the UG network.

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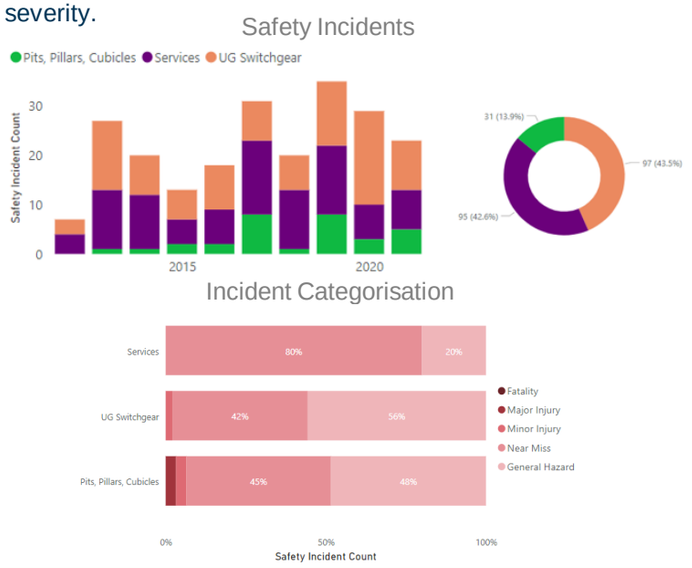
Performance

Historical performance of assets over the last 10 years has been used to inform consequence of failure modelling and can be linked to the network objectives to enable the measurement of performance against targets set. Data for safety incidents, reliability outages, resilience and utilisation is presented to identify the trend of incidents and compare asset class performance. It is noted that 2021 data may have gaps due to the transition to SAP, and improvements are required to data capture methods to ensure incidents are accurately recorded against asset class and asset type.

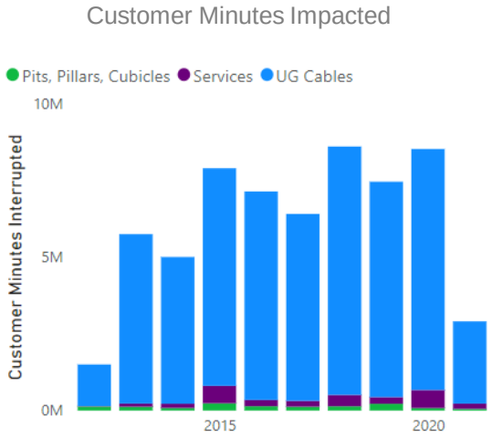
Safety

- The largest proportion of safety incidents can be attributed to UG switchgear, however this is driven by general hazards and near misses (98%).
- Over the last five years, safety incidents have been trending up when considered holistically. This is driven by an increasing trend in general hazards, with spikes in 2017 and 2019. Major and minor injuries have been trending down in this period and near misses have been steady. Injuries are considered to be major when hospitalisation is required.
- These trends should be monitored to ensure the increase in general hazards does not translate to an increase incident severity.



Reliability

- Outages have been increasing over the last 5 years, with UG cables contributing the most customer minutes impacted.
- The majority of failure have been caused by the cable joints or terminations where the electrical stresses on the cable are the highest.
- Over the last five years, the reliability incidents for UG cables have been trending up when considered holistically, whilst services and pits, pillars, cubicles have remained stable.



Resilience

Under development

Utilisation

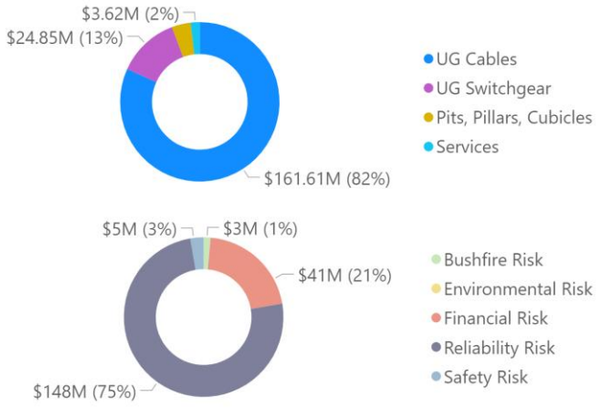
Under development

Risk

Failures of assets within the underground network system may lead to Bushfire, Environmental, Financial, Reliability, and Safety consequences. Risk measures are calculated to quantify these consequences at an asset level as per the current value framework. Endeavour Energy's risk forecast considers two scenarios which are compared to the baseline. The baseline and these two scenarios are defined as following:

Baseline: A risk forecast considering assets are replaced reactively as per the BAU and no planned interventions take place
Unconstrained: A risk forecast considering assets are replaced reactively as per the BAU + identified risk based interventions assuming no business constraints
Optimised: A risk forecast considering assets are replaced reactively as per the BAU + identified risk based interventions + business constraints

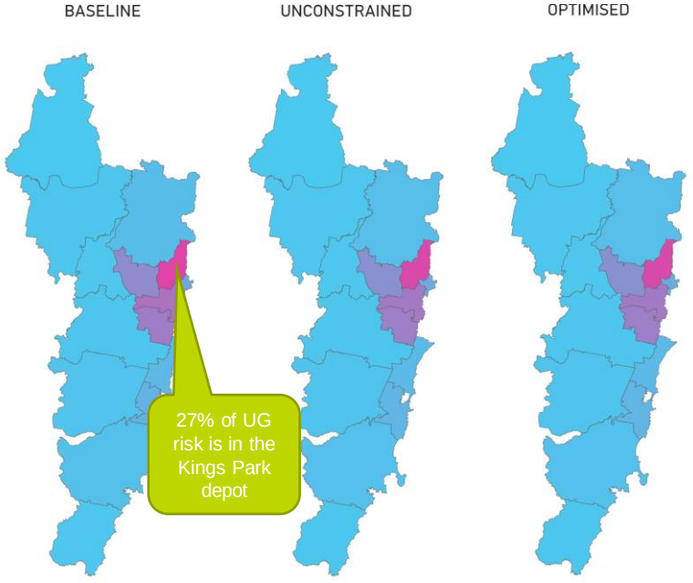
What's driving risk?



The baseline risk associated with the underground network over the next 10 years is mostly driven by cables representing over 80% of the total risk.

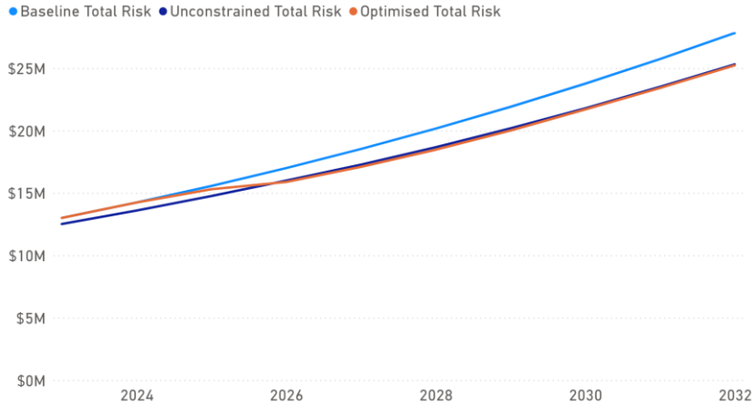
This risk is primarily composed of reliability, representing 75% of total risk. As these assets are underground, safety and bushfire risks are minimised representing less than 5% of the total risk.

Where's the risk?



The total risk associated with the underground network over the next 10 years is concentrated in higher density residential / CBD areas as the risk is predominantly driven by network reliability. The proposed strategy will continue addressing failures in these zones in a mostly reactive manner.

What's the risk going forward?



The baseline risk associated with the overhead network is projected to approximately increase to $28M if no action is taken.

The proposed unconstrained investment profile if carried out results in a slightly lower risk profile at $25M at the end of the 10-year forecast period.

Optimisation of the investment profile is largely similar to the unconstrained approach and therefore results in a similar risk profile at $25M at the end of the 10-year forecast.

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Investment Strategy

What did we consider?

Legend:

Not feasible or applicable	Selected Intervention	Partially Addresses Objective

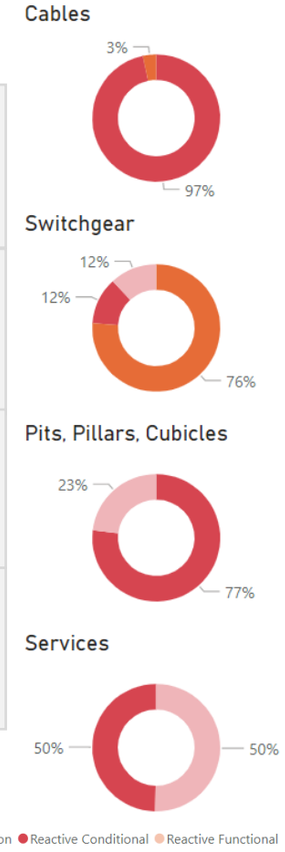
Asset Class	Non-network	Additional Maintenance	Reactive repair /replacement	Operational Controls	Reduced Load	Staged removal /replacement
Cables						
Switchgear						
Pits, Pillars, Cubicles						
Services						

Cables Intervention Strategy: Proactive intervention was considered to provide highest overall value in addressing risk and performance across 23.7 km of oil filled and other cables. Reactive replacement programs have been proposed to address residual failure risk.

Switchgear Intervention Strategy: Proactive intervention was considered to provide highest overall value in addressing risk and performance across 904 HV distribution combination switchgear. Reactive replacement programs have been proposed to address residual failure risk.

Pits, Pillars, Cubicles Intervention Strategy: Proactive intervention was considered to provide highest overall value. A primarily reactive strategy has however been proposed to address asset risk. This provided better cost balance given the geographic spread of the defective assets

Services Intervention Strategy: Proactive intervention was considered to provide highest overall value. A primarily reactive strategy has however been proposed to address asset risk. This provided better cost balance given the geographic spread of the defective assets.



The credible intervention options considered for this system are summarised above. Operational controls are effective in addressing safety performance but do not contribute sufficiently to other performance objectives. Reactive repair and replacement programs are justified for all asset classes. Staged removal and risk based replacement programs effectively address the performance objectives for cables and switchgear, but not provide sufficient value for selection as the preferred intervention for pits, pillars, cubicles and services.

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Investment Strategy

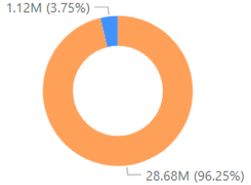
How have investments been identified?

The risked based replacement program has identified assets within the underground network that are justified for risk-based intervention in the upcoming regulatory period.

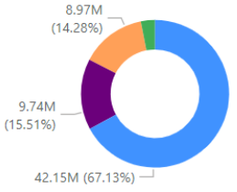
Assets that reach their maximum NPV are illustrated in the unconstrained scenario. A number of other assets will have reached the point of being NPV positive, however these will be considered as part of the portfolio optimisation process.

Total replacement volumes are comprised of risk based as well as reactive functional and conditional replacements based on the strategy selected for each asset class. Across FY23-32, the total unconstrained cost of risk based investments is $33.4M and reactive investments is $106.2M. Charts below reflect 10 year forecasts.

Risk Based by Asset Class



Reactive by Asset Class



Asset Class Pits, Pillars, Cubicles Services UG Cables UG Switchgear

Underground switchgear replacements drives the *volume and cost* of risk based investments

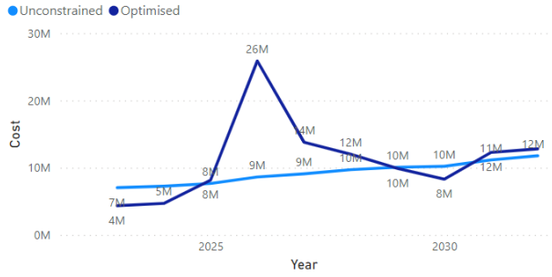
60% of Underground network assets are located in 3 depots: Hoxton Park, Kings Park and Narellan

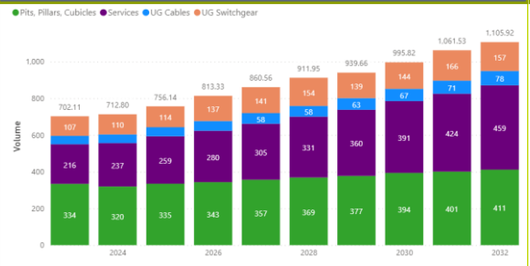
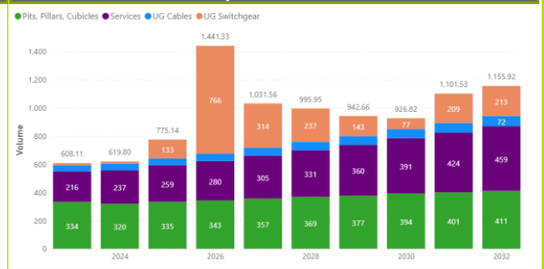
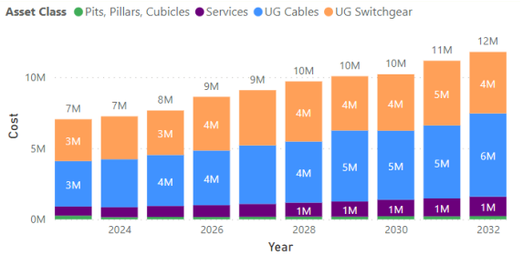
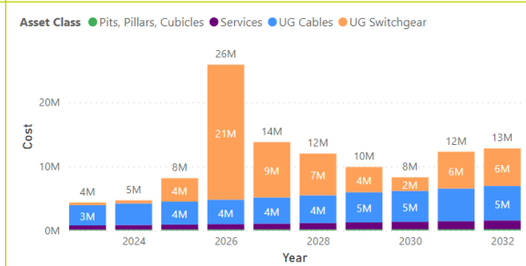
Comparison between unconstrained and optimised

The proposed unconstrained investment profile is calculated from FY23; however, it is difficult to efficiently introduce these additional replacements into the FY23 and FY24 periods without impacting existing strategies. Optimisation has been applied to these proposed investments, considering factors such as labour, outage availability etc.

Optimisation results in a proportion of assets identified for intervention in FY23 and FY24 being shifted into the next regulatory period. Additional smoothing of this profile is expected once labour / resourcing constraints are considered.

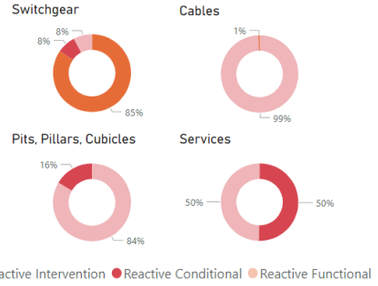
Unconstrained and Optimised Costs per Annum



	Unconstrained	Optimised
Volume		
Cost		

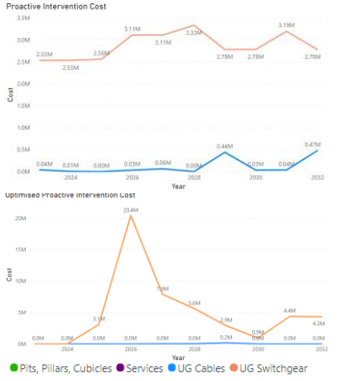
So What?

Cost of Optimised Risk Based and Reactive Investments



Asset classes with risk based investments include UG cables and Switchgear. Once optimised, the proactive spend across these asset classes has reduced in FY23-24 and increased in FY25-29. This is primarily evident for UG Switchgear.

Cost of Unconstrained and Optimised Proactive Investments by Asset Class



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Support Systems & Continuous Improvement

Support Systems

Ellipse Database

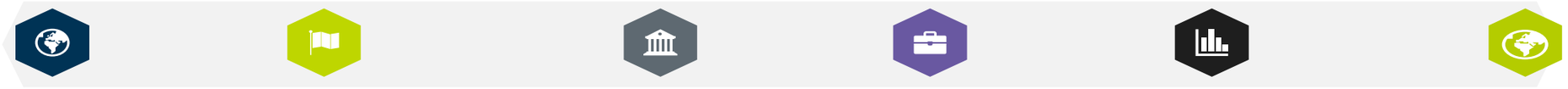
Used for historical (2010-2021) asset nameplate details, routine maintenance scheduling, defect workorder recording and management

OMS

Used for historic (2012-2021) asset related reliability incidents

MySafe

Used for historic (2012-2021) asset related safety incidents categorised by severity



SAP

Used for recent (2021-Current) asset nameplate details, routine maintenance scheduling, defect workorder recording and management

ADMS

To be used in future as the primary data source for: Reliability, Resilience, Utilisation metrics.

GIS

Used for historic (2012-2021) geo-spatial locations for linear assets.

Continuous Improvement

Data Capture and Completeness

- Improvement in data capture methods for reliability data to ensure events are recorded against asset class and asset type, and easily aligned to asset identification numbers in SAP.
- The safety data captured on MySafe does not categorize the safety incidents based on the asset type, which can be improved on in the next regulatory period with the use of SAP.

Alignment with Network Business Strategy

- Continuous monitoring and review of risk and performance modelling across all performance objectives and asset classes.
- Interpretation of risk forecasts for selected strategies to forecast performance trends by measure and asset class.
- Development of targets in alignment with Network Objectives to improve the quantification of system performance.

Performance Based /Forecasting

- Development of methods to target performance-based investments to ensure performance targets are achieved.

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